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BY ORDER OF THE

# BOARD OF HEALTH,

OF THE

# CITY OF ROCHESTER.

## *The Relations of Typhoid Fever to Contaminated Well-Water.*

## PROF. LATTIMORE'S REPORT,

ON THE CHEMICAL ANALYSIS OF WATER FROM FORTY SUSPECTED WELLS.



### *Why Well-Water is Liable to Contamination.*

The discovery last summer of the contaminated well at the corner of Hunter and Reynolds streets. and the indisputable fact that over forty persons who had used the waters from this well were sick with typhoid fever and other zymotic diseases, and whose recovery was rapid when the well was closed and no water could be obtained from it, led the health officer, Dr. Buckley, under direction of the Board of Health, some two months since, to request all physicians in the city to report the names and residences of all patients sick with typhoid fever. Some fifty cases have been reported; as they were reported health inspectors were sent to the premises, and they inquired into their sanitary conditions; the distance of cess pools, sewers and privy vaults from the wells, and whether the patients drank well water either "at home" or at places of business. Samples of water were taken from the wells and given to Prof. Lattimore for analysis.

Out of the whole number of cases reported, all but two were in the habitual use of well water. The exceptional cases arose from ill-ventilated apartments in close proximity to foul water closets. It was also ascertained that a very large number of the wells in the city were situated within an average distance of less than thirty feet from cess pools and privy vaults, while a great many were within ten feet of the poison-breeding places.

The analyses of Prof. Lattimore of the waters furnished him, possess such startling interest to every citizen, that the Board of Health publishes them in this official manner, together with the accompanying remarks of the Professor. Attention is especially directed to the statement of Prof. Lattimore, that while the waters furnished him were mostly sparkling and clear, the analyses showed them highly charged with the poisons, one of the admitted causations of typhoid fever. The Professor doubts whether there is a well of pure water in the city of Rochester.

*To the Board of Health and the Executive Board of the City of Rochester:*

GENTLEMEN: I respectfully submit the following report of the chemical examination, made at your request, of samples of water taken from forty suspected wells in this city. The samples were obtained by the Inspectors, under direction of the Health Officer, from premises where one or more cases of typhoid fever had been reported by the attending physician.

The following table shows such analytical results as are useful in forming a correct estimate of the sanitary character of these waters. The first column shows the total number of grains of all solid substances of whatever kind held in solution in one gallon of water. This is the residue left on evaporating a carefully measured volume of the water at steam heat. The second column shows the number of grains of chloride of sodium—common salt—per gallon. The third column shows the proportion of

With the compliments of

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ammonia already existing in the water. It is separated from the fixed substances by distillation, and is termed Free Ammonia. The fourth column shows the ammonia which is yielded by the nitrogenous organic matter in the water which has not yet undergone complete decomposition. It is obtained by treating the residue from the previous process by an oxidizing alkaline reagent and distillation. It is entered as Albuminoid Ammonia.

As these figures must derive their chief significance for all except chemists from a comparison with figures which express the sanitary quality of unsuspected waters, I have placed at the head of the list, for this purpose, the results of the analysis of two unsuspected waters. The first is the Hemlock Lake water as drawn from the city mains—a water of almost unsurpassed purity. The second is from the well in the University Campus, on the eastern side of the city, and I cite it as a fair standard of comparison, since from the nature of the soil and the surroundings it is probably as free from contamination by sewage or house drainage as any well in the city. I know of but one well in the city which contains a smaller proportion of solid matter in solution, and of none which contains so small a proportion of salt.

—Grains per U. S. Gallon.—

| Locality. | Total Solids. Residue. | Chloride of Sodium. | Free Ammonia. | Albuminoid Ammonia. |
|---|---|---|---|---|
| Hemlock lake | 6.40 | trace | .000 | .001 |
| University campus | 17.50 | 1.36 | .000 | .000 |
| 1. N. St. Paul street | 23.33 | 5.45 | .012 | .010 |
| 2. Lake avenue | 26.36 | 2.72 | .015 | .010 |
| 3. Meigs street | 36.16 | 5.41 | .010 | .012 |
| 4. Clifford street | 41.52 | 5.45 | .012 | .002 |
| 5. Caledonia avenue | 43.14 | 5.45 | .015 | .020 |
| 6. King street | 43.85 | 8.18 | .014 | .015 |
| 7. Gregory street | 45.49 | 5.46 | .020 | .025 |
| 8. Comfort street | 45.49 | 8.18 | .016 | .018 |
| 9. Sanford street | 55.29 | 6.82 | .015 | .010 |
| 10. Cayuga place | 55.99 | 9.55 | .020 | .020 |
| 11. Thompson street | 56.69 | 10.91 | .015 | .050 |
| 12. Ward street | 59.48 | 12.27 | .012 | .020 |
| 13. St. Joseph street | 61.25 | 8.86 | .004 | .008 |
| 14. Gorham street | 61.35 | 20.46 | .015 | .025 |
| 15. State street | 64.15 | 10.91 | .000 | .015 |
| 16. S. Ford street | 64.15 | 9.55 | .058 | .029 |
| 17. Pinnacle avenue | 64.15 | 12.27 | .050 | .020 |
| 18. Brighton brick yard | 68.82 | 13.64 | .040 | .030 |
| 19. Sellinger street | 72.31 | 15.00 | .001 | .001 |
| 20. Brown's alley | 76.98 | 9.55 | .091 | .012 |
| 21. N. Clinton street | 78.38 | 17.73 | .020 | .025 |
| 22. Shamrock street | 80.48 | 17.73 | .001 | .015 |
| 23. Rauber street | 82.01 | 21.83 | .045 | .020 |
| 24. Conklin street | 83.51 | 20.46 | .020 | .015 |
| 25. Jones street | 87.01 | 27.87 | .025 | .020 |
| 26. Davis street | 90.98 | 17.73 | .015 | .020 |
| 27. Nassau street | 90.98 | 19.09 | .020 | .025 |
| 28. Elizabeth place | 93.31 | 16.36 | .001 | .016 |
| 29. Catharine street | 93.31 | 16.36 | .025 | .015 |
| 30. Chatham street | 95.65 | 24.55 | .029 | .015 |
| 31. Pinnacle avenue | 98.67 | 27.27 | .050 | .025 |
| 32. State street, a | 99.14 | 31.36 | 1.500 | .375 |
| " " b | 97.19 | 30.00 | 1.475 | .372 |
| " " c | 97.97 | 27.27 | 1.510 | .370 |
| 33. Marietta street | 100.31 | 27.27 | .001 | .014 |
| 34. Savannah street | 101.47 | 16.36 | .012 | .015 |
| 35. N. St. Paul street | 103.81 | 16.36 | .025 | .020 |
| 36. Exchange street | 104.97 | 19.09 | .850 | .425 |
| 37. Maple street | 109.87 | 21.82 | .050 | .075 |
| 38. Mt. Hope ave | 110.80 | 17.73 | .015 | .010 |
| 39. Brighton brick yard | 111.50 | 32.73 | .120 | .025 |
| 40. E. Main street | 124.80 | 51.82 | .250 | .500 |

Average, 16.78 grains of salt per gallon.

A glance at the first column of the table shows that the total quantity of solid substances held in solution in all these suspected waters is very large. It is no exaggeration to pronounce it enormous in the latter half of the list. While it is true that the soil which underlies this city varies greatly in its qualities in different sections, and that the water contained in the soil must vary accordingly, it is scarcely possible that such quantities of matter in solution as are exhibited by the lowest of these figures, should have been derived from an unpolluted soil.

I would direct your special attention, however, to the second column, which shows the number of grains of common salt per gallon of water. No single indication is of so great sanitary importance in judging of the purity or impurity, and consequently of the safety or danger, of any water. How a substance, which is in itself not only harmless, but by most persons considered indispensable as an article of diet, becomes to the sanitarian a signal of danger in well water, will be easily rendered apparent. No mineral substance is perhaps so universally diffused as common salt. It exists in the air, hence in all rain water; in all soils, hence in all well or spring water, though often in quantities too minute to be weighed upon the chemist's balance, as is the case in the Hemlock Lake water supply of this city. Salt being remarkably soluble, it is constantly being washed out of the soil into the streams, and ultimately carried down to its great reservoir, the ocean. We may, therefore, expect to find salt present in all ordinary well waters. What might fairly be considered as the average proportion for uncontaminated well water in Rochester can be only estimated, but it certainly can not be large. Rivers may derive large quantities of salt from the drainage of manufacturing establishments upon their banks, but wells are not usually thus affected. Therefore, whenever, in well water, it rises above a very few grains per gallon, it becomes certain that it comes from some other source than the soil. What is that source? A moment's reflection will convince any one that nearly all the salt used for domestic purposes escapes by the way of two channels—the water closet and the house drain. Therefore, we should expect, what is always found on examination to be true, that whatever sewage may or may not contain, it always contains salt.

If sewage finds its way to a well through a porous soil, or through crevices of the rock, it inevitably brings its salt with it. Since so indescribable a compound as sewage can not be directly measured or estimated by chemical means, we take advantage of its invariable constituent, which fortunately does admit of the most exact determination. Hence whenever the proportion of salt in well water rises above a very few grains per gallon, contamination by sewage or house drainage may be confidently asserted, and when it reaches the figures above cited—*from five to fifty grains per gallon*,—the danger becomes so imminent, that I have no hesitation in declaring that this evidence is sufficient to justify the Board of Health in the exercise of its legitimate power to protect the pub-

lic health by preventing the further use of water from these wells.

I am informed by the Health Officer that typhoid fever has occurred among those using water from most of these wells. How far the water may be a factor in the production of this, or other forms of disease, is a problem of great difficulty. One fact, however, is demonstrated,—typhoid fever does prevail among those using these waters, and these waters are all bad—except perhaps one,—so bad that I can only characterize most of them as vile and dangerous. Nevertheless several of them possess no bad odor or taste, and are clear and sparkling. It is not strange, therefore that nothing short of a chemical analysis, or a physiological test, in the form of a case of typhoid fever, can convince the public that water may be bright and clear and at the same time filthy and fatally poisonous. From one of the most highly polluted of the wells in the list given, soda water has been dispensed all summer by an unsuspecting dealer to an equally unsuspecting public.

Near the close of my investigation it seemed desirable to obtain some more definite notions of the proportion of salt contained in the sewage of this city. The Parliamentary Commission on the Domestic water supply of Great Britain assert that they found the drainage from sewers, middens, and cesspools, rich in salt. Twenty samples of sewage from English towns, in which the midden system prevailed, contained an average of 11.07 grains per gallon. Thirty-six samples from towns in which the water closet system prevailed, gave an average of 10.66 grains. At my request the Inspectors collected samples of sewage from the outlets of nine of the principal sewers of this city, and in these samples I have determined by analysis the proportion of salt contained in each. The results are as follows:

| | |
|---|---|
| Allen street sewer | 1.36 grains of salt per gallon |
| Platt " | 1.70 " " " " |
| N. St. Paul " | 2.39 " " " " |
| Andrews " | 3.41 " " " " |
| Lake ave. " | 3.75 " " " " |
| Front street " | 4.41 " " " " |
| River " | 6.14 " " " " |
| Main " | 7.50 " " " " |
| North ave. " | 12.61 " " " " |
| Average | 4.81 " " " " |

The average proportion of salt found in these nine sewers is nearly three and a half times less than the average of the forty wells. The question naturally arises, why the sewage itself should present evidence of a lower degree of contamination than the wells? My answer is this: While the number of observations made, and the number of facts fully ascertained, are not yet sufficiently great to warrant positive conclusions, yet it seems to me probable that in this very disparity we may find at least an approximate indication as to whether a contaminated well water derives its impurity chiefly or entirely from dilute sewage, or from the privy vault and house drain, which may be considered as the source of the undiluted and concentrated sewage. Of course there may be, and doubtless are, many cases in the city where the same well derives organic matter from both these sources, since in several of the cases investigated the well and the privy were found in horrible proximity.

I would direct attention to the peculiar topographical and geological character of the site on which this city stands, and which renders its well water peculiarly liable to contamination. Everywhere, at no great depth beneath the surface, lies a stratum of limestone, containing much sulphate of lime and magnesian salts. In fact the residue left on evaporation of many of these waters is intensely bitter to the taste on account of the sulphate of magnesia—Epsom salts—which they contain.

The soil which covers this rocky formation consists, not of the "drift," which forms the general surface of this section of the country, but of aqueous deposits of separate beds of clay, sand, gravel and, in one or more parts of the city, beds of peat. One of the earliest "improvements" made in this city was to obstruct the natural drainage. The surface water which formerly flowed away by channels of its own making, is now compelled to sink more or less gradually into the earth. So soon as it reaches the rock it must stagnate underground, or find its way into a crevice or a well.

Many wells are excavated in beds of sand and gravel and do not reach the rock. They, therefore, drain all the neighboring higher ground and become receptacles for all soluble matters upon or in the soil for considerable distances. If a sewer passes near, its contents find their way into the well until it is filled up to the same level. Numerous wells in this city fluctuate as the sewer in the street ebbs or flows. Even in the beds of compact and impervious clay, where the chances of safety seem greatest, many underground streams and veins of water are found which may pass under a privy before they are tapped for domestic use. A most mistaken feeling of security is often entertained in a well because it is excavated in the solid rock.

A case precisely in point occurred in the course of this investigation. The owner of a well on State street—number 32 on the list—when apprised of the result of the analysis, expressed the most positive opinion that it did not fairly represent the character of the water, which he considered excellent. The well had been excavated into the solid rock, and an iron tube had been inserted, specially to prevent the entrance of surface drainage. He was positive that some error had been committed by the inspector, and asked permission to furnish a sample himself for analysis, to which I readily consented, suggesting that he should bring two samples—one drawn from the pump after standing, the other drawn from the bottom of the well. The samples were accordingly brought by the owner in person, and the three analyses are placed together in the list—number 32 (a) being that obtained by the Health Inspector, and number 32 (b) and 32 (c) those furnished by the owner. Although a month had elapsed between the taking of the samples, the difference in the results is but trifling. Though this water is clear, bright and colorless, it nevertheless contains the largest quantity of organic matter, as shown by the ammonia found in the entire list, thus evincing, as well as by the large amount of salt, the great extent of its concealed pollution.

This case fully illustrates the dangerous fallacy of judging by appearances, and approving a water simply because it is clear and odorless. Many of the samples of sewage were quite clear, and most of them without odor.

The fact that an excavation of no considerable depth, in almost any part of this city, is sure to fill with water, proves how thoroughly the strata of the underlying rock are filled with a net-work of crevices and seams through which the surface water is constantly finding its way to lower levels. I have no doubt this is the case with the well last mentioned.

Instances have not been infrequent in this city where the digging of a new sewer or the deepening of an old one has drained dry the wells of whole neighborhoods, much to the public indignation. Why such a thing could occur, was a question unasked, or if asked not followed to its logical conclusion. In such cases the usual remedy has generally proved efficacious, to retaliate by deepening the wells and draining the sewer!

## CONCLUSIONS.

The practical conclusions which have suggested themselves to my mind in the course of the analysis of these waters taken from forty suspected wells in this city, and which, through your publication of this report in tract form for general circulation, in the interests of the public health, I am enabled to submit to the consideration of all thoughtful citizens of Rochester, may be summed up briefly as follows:

1. The peculiar geological and topographical character of this city renders its wells, with rare exceptions, *extremely liable to pollution from surface drainage*. The entire area of the city is underlaid by the thick bedded limestone of the Niagara formation. This is covered to no considerable depth by deposits of clay, sand and gravel. Most of the wells are shallow, not reaching the rock, and are filled by the infiltration of water percolating the surrounding soil. If the well is excavated in the rock, it simply taps the net-work of crevices and seams by which the surface water sinks to lower levels. Therefore the deeper the well, the greater the danger of pollution.

2. Our so-called sewers, which, instead of being as they should be, impervious tubes, are simply covered ditches, from which their contents may escape almost as freely as they enter, serve, in their passage through our porous soil, as distributing mains, filling to their own level the wells, often for great distances on each side of their course. This state of things tends to the saturation of the soil with sewage and its permanent pollution, which must only grow worse with the lapse of time and the increase of population, unless some radical improvement is made speedily and systematically. A polluted soil ensures polluted air, which may be no less dangerous than polluted water, but from which the escape is far more difficult.

3. It will be readily conceded that until medical science has demonstrated what is the specific cause of typhoid fever, or of other zymotic diseases, be it organic germ or inorganic poison, chemical science can not be fairly challenged to show where it is, or is not, or to identify it. Yet such a mass of evidence has already been accumulated by sanitarians, showing in the most conclusive way, that, in numerous instances, in fact, in nearly every case intelligently investigated, such diseases have been communicated to large numbers of persons by *something in the water*, and as chemical analysis has, in almost every such case, produced conclusive evidence of contamination from sewage or drainage, it appears that we may claim to be able at least to point out the lurking place of the common enemy, if we can not yet lay our hands on his individuality. I do not deny that zymotic disease may not be communicated through other media. I am only calling attention to the conclusive evidence that water is one, if not the chief medium.

4. I have already given the reasons generally accepted by chemists for regarding the presence of common salt, beyond a certain small quantity, in well water as the surest indication of sewage contamination. The average quantity of salt found by analysis in these forty wells, as detailed in the preceding table, reaches *the surprising figure of* 16.78 *grains per gallon*. This is more than three times the maximum quantity which the Parliamentary Commission, in their report on the Domestic Water Supply of Great Britain, pronounce compatible with safety, holding that any greater quantity must be derived from sewage. Out of 569 waters analyzed and pronounced safe for domestic use, only 53—less than 10 per cent.—contained so much as five grains of salt per gallon. For geological and geographical reasons, I am of the opinion that a lower standard should be chosen for well water in this city, and that any water of this immediate vicinity containing so much as three or four grains of salt per gallon should be at once discarded on suspicion.

5. The arguments and opinions expressed in this report may not find universal acceptance. However that may be, the facts brought to light by the labors of the Health Officer and by the chemical investigation are demonstrations. Here are fifty cases of Typhoid fever, or closely related disease reported by the attendant physicians to the Board of Health. *All of these patients, except two, used well water*. In all these forty wells examined, with but one exception, the quantity of salt exceeded five grains per gallon. I may add that the results of this investigation are perfectly accordant with my experience for a number of years past in the analysis of many well waters for physicians who have suspected them as the cause of Typhoid fever and other diseases. The relation of polluted well-water to these cases of Typhoid fever, if not absolutely demonstrated, seems at least sufficiently clear to guide to intelligent action. Long ago I became so thoroughly convinced of the danger of using well-water that I discarded it totally from my own household, and I most earnestly commend, as a prudential measure, the same course to my fellow citizens.

S. A. LATTIMORE.

University of Rochester, Sept. 29th, 1877.